Momentum Worksheet #1

Key
(name)

1. What is the momentum of a golf ball that has a mass of 60 g and is moving with a velocity of 70 $^{m}/_{s}$?

$p = mv$

$= (0.06\,kg)(70\,\frac{m}{s}) =$

p = $4.2\,kg\,\frac{m}{s}$ ✓

2. If, in problem #1, the impact between the club and the ball lasted 2.0×10^{-4} s, what ~~was the rate of change of momentum?~~ What force did the club apply?

Δp = impulse = Ft

$\frac{4.2\,kg\frac{m}{s}}{2 \times 10^{-4}\,s} = 21000\,N$

Δp = $2.1 \times 10^{4}\,N$ ✓

3. A girl holds a 2.0 kg rifle loosely and fires a bullet of mass 1.0 g. The muzzle velocity of the bullet is 150 $^{m}/_{s}$. What is the recoil velocity of the gun?

explosion

$\vec{p}_{before} = \vec{p}_{after}$

$0 = \vec{p}_{rifle} + \vec{p}_{bullet}$

$0 = (2kg)(\vec{v}_r) + (0.001kg)(150\,m/s)$

$v_r = -0.075\,\frac{m}{s}$ ← opposite to bullet

v = $-0.075\,m/s$ ✓

4. If the girl in problem #3 holds the gun tightly against her shoulder, the recoil velocity is less. Calculate the new recoil velocity if the girl's mass is 48 kg.

$0 = (2+48\,kg)\vec{v}_r + (0.001kg)(150\,m/s)$

$= -3 \times 10^{-3}\,\frac{m}{s}$

v_{new} = $-3.0 \times 10^{-3}\,m/s$ ✓

5. In a freight yard a train is being made up. An empty car, coasting at 10 $^{m}/_{s}$ strikes a stationary loaded car and they couple together. Each of the cars has a mass of 3000 kg when empty, and the loaded car contains 12,000 kg of bottled pop. With what speed do the coupled cars move?

$(3000)(10) + 0 = (18000)\vec{v}$

$\vec{v} = 1.6\,\frac{m}{s}$

v = $1.7\,m/s$ ✓

6. A space man of mass 80 kg carries an empty oxygen tank of mass 10 kg. He throws the tank away from himself with a speed of 2.0 $^{m}/_{s}$. With what velocity does the spaceman start to move through space?

before: (90kg) 0 m/s ⟩ after: (80kg) V + (10kg) 2 m/s

$0 = 80\vec{v} + 20\text{kgm/s}$

$\vec{v} = \overleftarrow{0.25\ m/s}$ opp. direction

$v = \underline{-0.25\ m/s}$ ✓

7. What force, acting for 0.0010 s, will change the velocity of a 100 g baseball from 30 $^{m}/_{s}$ EAST to 40 $^{m}/_{s}$ WEST?

impulse

$F\Delta t = m\Delta v$

$F = \dfrac{(0.1\text{kg})(40\text{W} - -30\text{W})}{0.001\text{s}}$

$F = \underline{7.0\times10^{3}\text{N}}$ ✓

8. A ball of mass 3.0 kg, moving at 2.0 $^{m}/_{s}$ east, strikes head-on a ball of mass 1.0 kg that is moving at 2.0 $^{m}/_{s}$ west. The balls stick together after the impact. What is the velocity of the combined mass after the impact?

E +
W −

$m_1v_1 + m_2v_2 = (m_1 + m_2)v_{12}$

$(3\text{kg})(2\text{m/s}) + (1\text{kg})(-2) = (4\text{kg})\,v_{12}$

$v_{12} = +1\ \frac{m}{s}$

$v_F = \underline{1.0\ \frac{m}{s}\ [E]}$ ✓

9. A life raft of mass 180 kg carries two swimmers of mass 50 kg and 80 kg respectively. The raft is initially <u>at rest</u>; then the swimmers simultaneously dive off opposite ends of the raft each with a horizontal velocity of 3.0 $^{m}/_{s}$. With what velocity does the raft move?

+ −

$0 = 50\text{kg}(3\ \frac{m}{s}) + 80\text{kg}(-3\text{m/s}) + 180\text{kg}(v_r)$

$v_r = +0.50\ \frac{m}{s}$

$v = \underline{0.50\ m/s}$ in pos direction (toward 50 kg swimmer) ✓

Answers: 1. 4.2 $^{kgm}/_{s}$ 2. ~~21,000N~~ 2.1×10^{4}N ✓ 3. -0.075 $^{m}/_{s}$ 4. -0.0030 $^{m}/_{s}$ 5. 1.7 $^{m}/_{s}$
6. -0.25 $^{m}/_{s}$ 7. ~~7000N~~ 7.0×10^{3}N ✓ 8. 1.0 $^{m}/_{s}$ [E] 9. 0.50 $^{m}/_{s}$ toward 50 kg swimmer

Momentum Worksheet#2

_____.
(name)

1. A body of mass 5.0 kg travelling at a speed of 13 m/s in a certain direction has its speed reduced to 5.0 m/s in the same direction in a time interval of 2.5 s. What is the average ~~retarding~~ decelerating ✓ force acting on the body?

$F\Delta t = m\Delta v$

$F = \frac{5kg(5-13\,m/s)}{2.5s} = -16\,N$

Force that slows.

F_{av} = −16 N ✓

$V_0 = 0$

2. An airplane of mass 52,000 kg accelerates uniformly along a runway and takes off at a speed of 72 m/s after a run lasting 56 s. What is the thrust exerted by the engines and how far does the plane travel during takeoff? F = ? d = ?

$F\Delta t = m\Delta v$

$F = \frac{(52000kg)(72\,m/s)}{56s}$

$= 66{,}857\,N$

$d = ?$, $V_0 = 0$, $V_f = 72\,m/s$, $t = 56s$

$d = \frac{V_0 + V_f}{2} \cdot t$

$= 36 \cdot 56 = 2016\,m$

F = 6.7×10^4 N ✓

d = 2.0×10^3 m ✓ ✓

3. A tennis ball of mass 55 g strikes a racket at a speed of 7.0 m/s and after the collision it travels at a speed of 8.0 m/s in the opposite direction. If the collision lasts for approximately 0.12 s, what is the average force exerted by the racket on the ball?

$m = 0.055kg$

$\Delta V = -8\,m/s - 7\,m/s = -15\,m/s$

$t = 0.12\,s$

$F = ?$

$F\Delta t = m\Delta v$

$F = \frac{(0.055kg)(-15\,m/s)}{0.12s}$

$= -6.875\,N$

indicates opp. direction to ball's initial direction

F_{av} = −6.9 N ✓

4. A rifle bullet of mass 64 g leaves the muzzle with a speed of 550 m/s. If the rifle itself has a mass of 7.5 kg, what is the speed at which the rifle recoils?

$0 = P_{rifle} + P_{bullet}$

$= (7.5kg)V_r + (0.064kg)(550\,m/s)$

$V_r = -4.693\,m/s$

opp. direction to bullet

V_R = −4.7 m/s ✓

★ tonne ✓

give → 1000 kg = 1 tonne

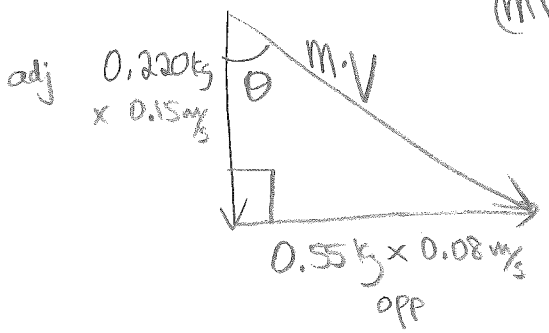
5. A boxcar weighing 64 ~~tones~~ travelling at a speed of 4.0 $^{m}/_{s}$ collides with a stationary flatcar weighing 48 ~~tones~~. If the couplings engage, what is the final speed of both cars?

$(64\times10^{3}\,kg)(4\,m/s) + 0 = ((64+48)\times10^{3}\,kg)\,V_f$

$V_f = 2.2857$

$V_F =$ 2.3 m/s ✓

6. A steel ball of mass 220 g moving at a speed of 15 $^{cm}/_{s}$ south on a level table collides inelastically with a second ball of mass 550 g, travelling at a speed of 8.0 $^{cm}/_{s}$ east. If the two balls stick together, what is the common final velocity of the two balls?



$(mV_f)^2 = (0.22\cdot0.15)^2 + (0.55\cdot0.08)^2$

$V_f = \sqrt{1.089\times10^{-3} + 1.936\times10^{-3}}$

$mV_f = 0.055\,m/s$

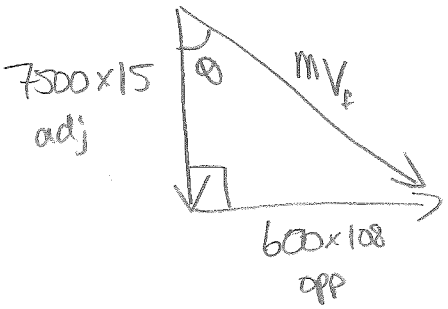
$V_f = \dfrac{0.055\,m/s}{0.77\,kg}$

$\tan\theta = \frac{opp}{adj}$

$\theta = 53°$ E of S

$V_F =$ 0.071 m/s [53° E of S] ✓ or [37° S of E]

7. A truck weighing 7,500 kg travelling with a speed of 15 $^{km}/_{h}$ south on an icy road collides with a minicar weighing 600 kg travelling at 108 $^{km}/_{h}$ east. What is the common final velocity of the wreckage? stick together



$(mV_f)^2 = (600\cdot108)^2 + (7500\cdot15)^2$

$mV_f = 129827.9$

$V_f = \dfrac{129827.9}{8100\,kg} = 16.028$

$\tan\theta = \frac{opp}{adj}$

$\theta = 30°$

$V_F =$ 16 km/hr [30° E of S] ✓

Answers: 1. -16N 2. 6.7 x 10^{4}N, 2.9x10^{3}m 3. -6.9N 4. -4.7 $^{m}/_{s}$ 5. 2.3 $^{m}/_{s}$
6. 0.071 $^{m}/_{s}$, 37° S of E 7. 16 $^{km}/_{h}$ 60° S of E

Momentum Worksheet #3 _____.

(name)

1. A 50 kg cart is moving across a frictionless floor at 2.0 m/s. A 70 kg person riding on the cart, jumps off the back of the cart so that he lands on the floor at zero velocity.
(a) What impulse did the person give to the cart?

impulse = $m\Delta V$

$= 70kg(0 - 2.0m/s)$

$= -140\ N\cdot s$

$\Delta p =$ $-140 N\cdot s$ ✓

(b) What is the velocity of the cart immediately after the person jumped off?

$140kg\frac{m}{s} = mV$

added original speed

$V + 2m/s$

$2.8 + 2$

$140 = 50V$

$\frac{140}{50} = V = 2.8\frac{m}{s}$ given extra

$v_c =$ $4.8 m/s$ ✓

2. A stationary billiard ball is struck by a similar ball, which was originally moving north at a speed v_0. The target ball moves off at 30° west of north and the incident ball moves off at 60° east of north. Calculate the speed of each ball after the collision in terms of v_0.

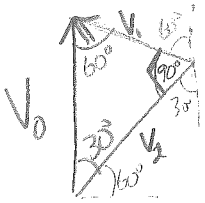
before

$V_1 = V_0$

0 m/s

after

same masses so can just use V



$\frac{V_1}{\sin 30°} = \frac{V_0}{\sin 90°}$ (1)

$V_1 = 0.5V_0$

$\frac{V_2}{\sin 60} = \frac{V_0}{\sin 90°}$ (1)

$V_2 = 0.866V_0$

$v_1 =$ $0.5 V_0$. ✓

$v_2 =$ $0.866 V_0$. ✓

Answers:
1. (a)-140 Ns (b) 4.8 m/s in original direction 2. 0.50 v_0 and 0.866v_0

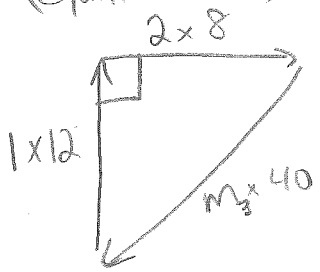
Momentum Worksheet #4 _____.

(name)

$P_{before} = 0$

1. An explosion blows a rock into three parts. Two pieces go off at right angles to each other, a 1.0 kg piece at 12 m/s and a 2.0 kg piece at 8.0 m/s. The third piece flies off at 40 m/s. What was the mass of the rock before the explosion?

① find m_3 (equilibrium Δ)



$(m_3 \times 40)^2 = 12^2 + 16^2$

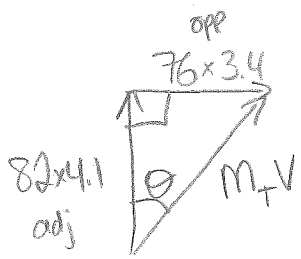
$m_3 = 0.5\,kg$

② Add all masses

$1kg + 2kg + 0.5kg = 3.5\,kg$

$m_3 =$ 3.5 kg ✓

2. Two tennis players, one of mass 82 kg and at a velocity of 4.1 m/s north, the other of mass 76 kg and at a velocity of 3.4 m/s east collide running for a ball. They lock together. What is their velocity while entangled?



$\sqrt{(158V)^2} = \sqrt{113030.44 + 66770.56}$

$V = \frac{\sqrt{179801}}{158}$

$= 2.68\,\frac{m}{s}$

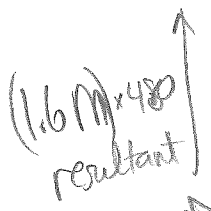
$\tan\theta = \frac{opp}{adj}$

$\theta = 37.546$

$v_t =$ 2.7 m/s [38° E of N] ✓

3. In an attempt to put a satellite into orbit, the rocket moving vertically upward at 480 m/s explodes into two pieces. One piece continues upward at an angle of 45° with the vertical at a speed of 350 m/s. What is the velocity of the second piece if its mass is 0.60 that of the first piece?

before



after

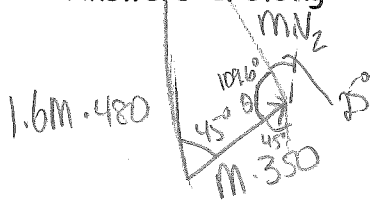
$\frac{\sin\theta}{1.6m \times 480} = \frac{\sin 45}{0.6m \times 960.5}$

$\theta = 70.4° \rightarrow 180 - 70.4 = 109.6$

$180 - 45 - 109.6 = 25.4°$

$v_2 =$ 9.6×10² m/s [25° off vertical]

Answers: 1. 3.5kg 2. 2.7 m/s, 38° E of N 3. ~~960~~ 9.6×10² m/s, 25° off of vertical



$(0.6mV)^2 = (1.6m \cdot 480)^2 + (350m)^2 - 2(1.6m \cdot 480)(350m)\cos 45°$

$V = \frac{\sqrt{589824m^2 + 122500m^2 - 380140.6m^2}}{0.6m} = 960.5\,\frac{m}{s}$